This JEM Report
is fondly dedicated to the
memory of our esteemed
colleague and friend

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1. INTRODUCTION

The T1P1 Technical Subcommittee of Committee T1 and the TR45.4 Subcommittee of Telecommunication Industry Association (TIA), in April 1992, determined the need to jointly examine the issues related to air interface technology, standards, applications and services in the context of Personal Communications. In August 1992, their parent organizations, committees T1 and TR45, authorized to convene a Joint Experts Meeting (JEM) in November 1992, to address the four objectives below, and welcomed the participation of Telocator, the Personal Communications Industry Association, to co-host the event.

The JEM objectives were as follows:

1. Solicit industry views on air interface Standards that are required to support Personal Communications Services (PCS) with emphasis on applications in the Americas over the next decade.

2. Based upon considerations of service demand and technology, determine which applications require distinct air interface Standards.

3. Address the issue of the need and advantages of developing a minimum number of air interface Standards, that allow similar applications from a technical and end-user point-of-view to be served with the same air interface.

4. Reach consensus on an industry-needs driven schedule for required air interface Standards.

A set of reference documents were identified to guide the discussions, and a total of fifty nine (59) contributions were received to be addressed in the specific sessions covering the objectives.

The JEM was called to order on November 10, 1992, at Reston, VA, by Co-Chairs Charles Cook and Wing Lo. About 120 representatives from US standards organizations, European and Interamerican standards groups, US trade industry associations, North American service providers, industry and Canadian and US regulatory agencies attended and participated in the deliberations.

The JEM was sponsored by AT&T, Northern Telecom, Motorola Inc., Rockwell International and Southwestern Bell Technology Resources.

2. PURPOSE

The purpose of this report is to register the consensus agreements and recommendations achieved during the discussions of the four objectives and to present them to the Joint Technical Committee (JTC) on wireless access and subcommittees T1P1 and TR45.4 for analysis and decision on implementation.

These deliberations were held between November 9 to 13, 1992. To facilitate the proceedings, a one day symposium was held where speakers from various standard bodies, service provider associations and regulatory agencies gave their views on PCS. The remaining four days were spent on deliberations and producing of this report. As a matter of record the agenda is shown in Appendix A.

3. RELEVANT ISSUES AND RECOMMENDATIONS

3.1 Related to Objective 1

Objective 1: Solicit industry views on air interface Standards that are required to support Personal Communications Services (PCS) with emphasis on applications in the Americas over the next decade.

Industry views on air interfaces for personal communications were solicited and received from US standards groups T1P1, TIA, and IEEE P802.11, European standards organization ETSI - SMG5, Consultative Committee of International Radio (CCIR) TG8/1, Interamerican telecommunications organization Interamerican Conference of Telecommunications (CITEL), the Canadian regulatory agency Department of Communications (DOC), the Federal Communications Commission (FCC), and US trade industry associations - Cellular Telecommunications Industry Association (CTIA), Wireless Information Networks Forum (WINForum) and Telocator.

Some of the views from the industry were presented during the one day symposium preceding the deliberations. The common theme throughout the day was that there was a need for co-operation between various standard organizations. TIA representative stated that there was a need for "Future Proofing" of wireless standards. This requires for the standards to be sufficiently flexible to accommodate technology changes. To reduce standards development interval, consideration should be given to reuse of existing standard segments.

Telocator representative in his presentation requested the development of standards in a timely manner. He urged the standard bodies to avoid competition amongst themselves. He also stated the need to harmonize with international standards. T1P1 speakers also supported the joint development of standards. Consideration of international activities relative to PCS was also a common theme.

Specific topics were addressed in the fifty nine (59) contributions received from industry organizations and participating companies and classified in accordance to the working objectives.

3.2 Related to Objective 2

3.2.1 Introduction

Objective 2: Based on considerations of service demand and technology, determine which applications require distinct air interface standards.

This objective was broken into the following questions:

- What services and applications are desired by the users, and what is the minimum set of services required to be supported over the air interface?
- What are the physical "operating environments" that will be encountered and what are the technical issues driving the design of an air interface to provide service in each operating environment?
- What constraints will be imposed by the potential need to share spectrum with existing microwave users?

Services Aspects, Technology Issues and Spectrum Sharing Aspects subgroups were formed. The results and recommendations of these activities are described here.

3.2.2 Services Aspects

3.2.2.1 Issues and Discussion

The JEM attempted to identify which services have significant impact on the air interface.

The JEM agreed that there are several different service/operating environments that could impact radio systems and air interface design. These service/operating environments are:

1) indoor residence

2) indoor office

3) indoor commercial

4) outdoor vehicular

5) outdoor pedestrian

6) wireless loop

These environments were considered when discussing the services impact on the radio interface.

Following are services and capabilities identified as impacting the air interface. While this is by no means an exhaustive list, it is felt to be representative of the range of air interface-impacting services. Associated with each is an indicator representing the believed degree of difficulty to implement and level of impact on the air interface design.

Service Capabilities	Impact
Audio	
Voice, land-line quality	M
Music, land-line quality	H
Voice/music, less than land-line quality (optionally user/service provider selectable, assumes multi-rate codec)	L
Data	
Voiceband - 2400 kbps	L
Voiceband - 9600 kbps	H
Digital, multi-rate via bearer channel aggregation	H
Packet (packet service with non-isochronous mode over the air)	H
Asymmetrical	H
Client/Server LAN	H
Bearer channel bit-count integrity	M
Video	
Slow-scan video (<= 19.2 kbps)	H
Control/Signaling	
Out-of-band signaling and messaging	M
Emergency, all channel busy (e.g., 911)	M
Multi-Level Precedence and Pre-emption (MLPP)	M
Inband signaling during connection	M
Invocation of network-based services/features	M
Passing/generation of DTMF to network elements	M
Terminal/service type to/from network (FAX/voice/data)	L
Universal Personal Telecommunication (UPT)	N(Note 1)
Identification and selection of service provider	L
Encrypted Authentication & Validation	L
Encryption	
End-to-end	M
Radio link encryption	M(Note 2)

Legend: N = no impact L = low impact
M = moderate impact H = high impact

Table 3.2.1 Expected Impact of Service Capabilities on Air Interface

Note 1: UPT is expected to be a network function that will add no additional complexity to the air interface beyond other services described herein.

Note 2: The insertion of radio link encryption should have no impact on service integrity. If it does, the capability should exist to disable encryption.

The JEM agreed that the radio system/air interface should be designed so as to allow graceful evolution to support future services and capabilities, including multimedia applications, terminal location and higher user data rates. It was also agreed that system performance was relevant and contribution TR45.JEM/92.11.09.266(T1P1/92-266) (T1P1 draft Technical Report "*System/Service Objectives for Low Power Air Interface for Personal Communications*"), Section 8 (less 8.5, 8.8, 8.9 and 8.10) was identified as appropriate text.

A second task was to look for consensus and develop a recommendation of the minimum set of services required to be carried over air interface(s) for each of the six operating environments. The services were classified into two categories: speech and data.

Minimum Speech and Data Services Requirements

The JEM assumed that a specific service provider (licensed) or equipment provider (non-licensed) may or may not utilize the full capabilities of the Air Interface; the term "requirement" refers to the Interface, not to the Provider. The JEM used the term "optional" to mean that the standards-making organization should not be required to design a feature into the Air Interface, but may do so if it is natural or easy.

The following two tables represent the identified minimum service capabilities for voice and data services. Note that the JEM expects that, in many cases, these minimum characteristics can and should be exceeded.

Speech Services	Indoor Residence	Indoor Office	Indoor C'mml.	Outdoor Vehicle	Outdoor Pedestrian	Wireless Loop
Voice Quality						
As Good As Wireline (Note 1)	Req.	Req.	Req.	Opt./Req.	Req.	Req.
Less Than Wireline	Optional.	Optional	Optional	Req./Optional	Optional	Optional
Program Audio	Optional	Optional	N/A	N/A	N/A	Optional
DTMF - Keypad	Req.	Req.	Req.	Req.	Req.	Req.
DTMF - Audio/Inband	Optional	Optional	Optional	Optional	Optional	Optional
Emergency Services (e.g.911)	Req.	Req.	Req.	Req.	Req.	Req.
Signaling to Support Supplementary Services	Req.	Req.	Req.	Req.	Req.	Req.
Mobility						
Registration/ Call Delivery	Optional	Req.	Req.	Req.	Req.	N/A
Handover	Optional	Req.	Req.	Req.	Req.	N/A
Privacy	Req.	Req.	Req.	Req.	Req.	Req.
Authentication	Req.	Req.	Req.	Req.	Req.	Req.

Table 3.2.2 Minimum Set of Speech Services

Note 1: Must support Music On Hold and Voice Recognition

Notes: Regarding the Table of Minimum Set of Speech Services

The following items were considered for minimal user expectations with regards to voice services. Parenthetical references relate to sections in TR45.JEM/92.11.09.266 (T1P1/92-266).

1. There was consensus that wireline-like speech quality be maintained, except on the issue of outdoor vehicular service, where the JEM was divided as to whether cost/capacity issues would tip the scales toward permitting lower quality. Music-On-Hold and Automatic Voice Recognition can be accommodated as long as the high-quality requirement is met.

2. On the other hand, the Air Interface may accommodate an option whereby a provider may offer a lower quality to which a customer may subscribe, for presumably a lower tariff.

3. Program Audio (7 kHz acoustic bandwidth) did not receive support as a requirement of the Air Interface; however, there was a feeling that the quiet indoor acoustic environments would warrant this feature as an Option.

4. DTMF (7.1.1): The JEM reached consensus that DTMF signaling must be supported, either by actual transmission of the tones or by network conversion of digital data messages into the tones. Whether acoustically coupled devices using such control tones can be used is an optional feature.

5. Emergency Services (e.g. "911"): General consensus that emergency services must be supported as a general requirement was reached. Detailed requirements, such as what to do if an emergency call encounters traffic blocking or how to deliver precise location information to the emergency bureau, are subjects for further study.

6. Support for supplementary services: It was agreed to require the signaling capabilities of the Air Interface to be adequate for all call processing and call management features listed in (7.1.3) of the T1P1 document. It is up to higher layers of the protocols to execute the supplementary services.

7. The mobility features of registration, call delivery during roaming, and handover are optional for the indoor residence environment, not applicable for the Wireless Local Loop case, and required for all the others. However, these are generally Layer 3 functions.

8. Sections of the report (9.3 and 9.14) were supported by a consensus within the JEM for requiring the Air Interface to provide privacy and authentication functions in all environments.

Data Services	Indoor Residenc.	Indoor Office	Indoor C'mml.	Outdoor Vehicle.	Outdoor Pedestrian	Wireless Loop
Interworking With PSTN Data Services (7.2.1.1)						
Min. Bit Rate (view #1)	2.4 kbps	9.6 kbps	2.4 kbps	2.4 kbps	2.4 kbps	2.4 kbps
Min. Bit Rate (view #2)	28.8 kbps	28.8 kbps	9.6 kbps	4.8 kbps	9.6 kbps	28.8 kbps
Interworking With Digital Data Services (7.2.1.2)						
Min. Bit Rate (view #1)	<---------- up to radio channel rate ---------->					
Min. Bit Rate (view #2)	64 kbps	128 kbps	<-- up to radio channel rate -->			64 kbps
Multiple Channels	Optional	Optional	Optional	Optional	Optional	Optional
Access to Packet Data Services	Req.	Req.	Req.	Req.	Req.	Req.
Blocking Prob. (8.1/8.5/8.8)	0.1%	0.1%	1-2%	2%	1-2%	0.1%
Data Quality (8.4/8.6)	error treatment required to achieve 10^{-5}					
Call Cutoff Prob. (8.7)	same as voice					
Network Access Delay (8.9)	same as voice					
Call Setup Delay (8.10)	same as voice					
Privacy (9.3.1)	Req.	Req.	Req.	Req.	Req.	Req.
Authentication	Req.	Req.	Req.	Req.	Req.	Req.
Handover (9.3.4/9.7)	for further discussion					

Table 3.2.3 Minimum Set of Data Services

Notes: Regarding the Table of Minimum Set of Data Services

The JEM reached consensus on all issues with one exception: the required bit rates. The view of the significant majority (view #1) was that a typical user would expect minimum rates to be the same as those which are minimally acceptable today, loosely defined as the typical "fall-back" rate of existing analog modems. The minority view (view #2) held that users will expect a minimum service equivalent to the maximum capabilities of the systems identified. Parenthetical references relate to sections in TR45.JEM/92.11.09.266 (T1P1/92-266):

1. Interworking with PSTN voiceband data services (7.2.1.1). Currently all voiceband data services are handled via a modem. The minimum requirements reflect the limitations associated therewith. Views #1 and #2 are reflected in the attached table.

2. Interworking with digital data services (7.2.1.2). View #1 motivates the belief that the rate of a single radio channel is an acceptable base on which to offer access to circuit switched digital services. (As an option, multiple channels can be used to increase the data throughput.) View #2 motivates radio equipment design which prevents it from being the limiting factor in the data transfer process, providing access equivalent to wireline circuit switched connections.

3. Packet data services (7.2.2). Access to packet data services is available today via wireline, and thus should be considered a minimum service capability of PCS systems. See below for a discussion.

4. Blocking Probability (8.1/8.5/8.8). Service access probability, blocking probability and availability were viewed as a single issue from the subscriber's point of view. The suggested blocking probabilities are delineated in the above table.

5. Data quality (8.4). Again, these are considered the same from a user service point of view. An end-to-end BER of 10^{-5} is considered acceptable. This is expected to be achieved via some sort of error treatment on the radio link, but particular schemes such as ARQ were not discussed.

6. Call Cutoff Probability/Network Access Delay/Call Setup Delay (8.7/8.9/8.10). It is felt the current users will accept a data service operating with the same parameters as voice service.

7. Privacy and authentication (9.3.1). Both are requirements for any voiceband data system as offered by a wireless service provider. The security level should be higher than that currently available with wired personal computers due to the fact radio signals can be intercepted without the knowledge of the system user.

8. Handover & Channel Bit Integrity (9.3.4/9.7/8.6). The particular method of handover implementation is not of concern to the end-

user. It is felt, however, that a handover mechanism must be developed which eliminates (or at least minimizes) the occurrence of a data call being dropped due to the momentary interruption of the channel. The handover also must not significantly complicate the encryption function.

3.2.2.1.1 Recommendations

1. The above tables give the recommendations made by the JEM as to the minimum service capabilities for voice and data services. Note that the JEM expects that, in many cases, these minimum characteristics can and should be exceeded.

2. The JEM recommends that the Air Interface support access to packet data services (both public and private packet networks). However, the JEM notes that the underlying implementation of the radio link access procedure that provides access to packet services may grant a dedicated radio link for the duration of the session, or it may rely on packet-by-packet contention for radio resources.

   The JEM voiced concern that the use of the same link access procedure for packet as for that of voice and circuit switched data services may not be optimal. This in turn may lead to the development of other link access procedures for access to packet data services which, if it takes place outside of the sanctioned standards process, would have the undesirable effect of the proliferation of non-standard air interfaces.

3. The JEM recommends that the Air Interface be defined so as to enable the cost effective design of a terminal that could be used both in licensed and non-licensed bands. The JEM notes that this is desired both by end users and service providers.

3.2.3 Technology Issues

3.2.3.1 Air Interface Proposals

More than six radio system air interface proposals were described. These proposals contained a variety of multiple access techniques (FDMA, TDMA, CDMA-DS, B-CDMA), duplexing methods, channel coding methods, and voice coding techniques.

3.2.3.1.1 Recommendation

The JEM recommends a comprehensive study of various air interface proposals to determine the applicability of various air interface technologies within the different operating environments.

3.2.3.2 Duplexing Methods

The two-way transmission of information must be provided in PCS. Two methods are generally considered:

1. Frequency Division Duplexing (FDD), in which the information flowing in each direction is transmitted on a different frequency, and

2. Time Division Duplexing (TDD), in which the information is transmitted on the same frequency, but with the channel rapidly alternating between the two directions of transmission.

The JEM agreed that the following salient differences in the two methods apply; all these points must be considered together.

- TDD is more appropriate where only a single continuous block of spectrum is allocated; FDD is more appropriate where paired blocks of spectrum are allocated.

- Delay considerations make TDD less suitable for cells with large radii..

- TDD is more sensitive to a lack of synchronization between base stations of a network.

- TDD doubles the required underlying radio transmission rate, making TDD more susceptible to inter-symbol interference than FDD.

- TDD may permit the implementation of antenna diversity to be simplified

- Hardware utilization is generally lower for TDD since radio equipment is generally idle for half the time.

- TDD simplifies spectrum sharing with fixed microwave compared to FDD.

3.2.3.2.1 Recommendation

The JEM recommends no action on duplexing schemes at this time.

3.2.3.3 Air Interfaces

One way to begin to define the air interfaces is to focus on where people will need (or are likely to use) wireless services. A view of the user needs and radio environment can then suggest technology compromises appropriate to these factors. A first step in this process is to list key characteristics of the radio channel and air interface, for each operating environment considered. This information can be combined with information on user needs, application requirements, wired and intelligent network requirements to assist in making the necessary technology compromises in designing a wireless access system for PCS. This process facilitates recommendation of appropriate power levels, bit rates, voice codecs, modulation schemes and access methods to accomplish the desired communications with minimum complexity and cost.

The JEM did not consider satellite, air-to-ground, or wideband LANs in this analysis.

The following two tables characterize a set of operating environments where users are expected to use PCS. The operating environments used were based on environments presented in CCIR Task Group 8/1 contribution TR45.JEM/92.11.09.259 (T1P1/92-259).

USER	User Speed	Fading Environment	Handover Window Interval	User Density	Speech Quality Impact (Delay)	Data Rate Req.
Wireless PBX	Low	Very Slow	Long	High	Low	Low/ Medium
Home Cordless	Low	Very Slow	Long	High	Low	Low/ Medium
Wireless Local Loop	Low	Very Slow	Long	High	Low	Low/ Medium
Pedestrian	Low/ Medium	Slow	Long	High	Low	Low/ Medium
Vehicular	High	Fast	Short/ Medium	Low/ Medium	Medium/High	Low

Table 3.2.4 View 1 of Qualitative Characterization of PCS Environment

ENVIRONMENT	Range[1]	Vocoding Delay	Delay Spread	Power	Hand-over	Speech Quality	User Density	Doppler
Office	200 ft	Low	Low	Low	Yes	High	Very High	None
Pedestrian	2000 ft	Low	Low	Low	Yes	High	High-Low	Low
Vehicular (Note 1)	3 mi	Moderate	High	High	Yes	Mod	Mod/ Low	High
Wireless Local Loop	2000 ft	Low	Low	Low	Yes	High	Mod/ High	Low
Public Buildings	500 ft	Low	Low	Low	Yes	High	High	None
Home / Multi-tenant	500 ft	Low	Low	Low	Yes (Note 2)	High	Low/ High	None

Table 3.2.5 View 2 of Qualitative Characterization of PCS Environment

Note 1: Use of communication service at moderate to high speed. This environment also includes low user density areas (e.g. rural).

Note 2: Handover may not be required in this environment.

3.2.3.3.1 Recommendations

1. Based on the above tables, it appears that a single air interface should be technically feasible for the following environments:

   - Office (WPBX / CENTREX)
   - Home (including multi-tenant)
   - Wireless local loop
   - Pedestrian (indoor / outdoor)

   This conclusion does not look at specific spectrum allocations, which may have a significant impact on air interface standards and does not dictate that a single air interface should be developed.

2. The vehicular environment places unique requirements on the air interface because of velocity of users and because of potentially larger cells and higher power requirements.

[1] Range is the distance between the terminal and the base station

While a different air interface is indicated for the vehicular environment, when a commonality in some technical parameters already exists (e.g. duplexing method, bandwidth and information rate) the proper use of other technical parameters (e.g. diversity, equalization, coding and interleaving, power level, etc.) can create a high degree of commonality between the air interfaces and the equipment that implements that interface. Network and subscriber unit cost benefits will occur if standards are developed with the aim of achieving this high-level commonality. Other benefits that will be derived include the simpler implementation of multi-air interface units and accompanying multi-environment applications.

This commonality is consistent with the core air interface concept being developed in CCIR, and discussed in contribution TR45.JEM/92.11.09.257 (T1P1/92-257).

3.2.4 Spectrum Sharing

3.2.4.1 Issues and Discussion

3.2.4.1.1 OFS/PCS Spectrum Sharing Issues

Based on the objective outlined at the beginning of the section, the following specific questions between operational fixed services (OFS) and PCS were addressed:

- Is spectrum sharing possible?
- Should there be a standard(s) for spectrum sharing?
- What is the relationship, if any, between the air interfaces and spectrum sharing technologies/standards?
- What is the role of the JTC or other standards bodies and industry fora relative to spectrum sharing?
- What are the technical characteristics of spectrum sharing relative to the development of air interface standard(s)?

3.2.4.1.2 Recommendations

1) With respect to the question of whether spectrum sharing is possible the JEM agreed that:

   - Licensed PCS Sharing with OFS is possible, as an interim step to facilitate the introduction of PCS, until clear spectrum becomes a reality.

- With appropriate mechanisms, non-licensed PCS sharing is a possibility, as an interim step to facilitate the introduction of PCS, until clear spectrum becomes a reality. The need for clear spectrum at the onset should not be precluded.

  It is recognized that there are cases where no spectrum clearing is required, for example, in areas where no PCS service is provided.

- International co-ordination between governments for border cities is required for PCS to operate in these areas.

- In the event, there is a potential for interference with OFS, Recommendations 2 to 6 shall apply.

2) The air interface should provide a wide range of capabilities and features that can be implemented by manufacturers or may be supported by operators depending on the specific application being addressed or service provided. Any air interface standard will need to enable the system to manage interference between OFS and PCS, and between PCS and PCS.

   The impacts and issues relative to spectrum sharing on the air interface between OFS and PCS were discussed. Consistent with the view that this aspect of spectrum sharing is primarily a transitional issue, the JEM recommends that:

   - the air interface standard(s) shall enable coexistence with existing fixed microwave services without compromising the long term service goals of PCS.

3) A common thread of the presentations was the requirement for the mobile/portable to know the OFS environment before it began transmitting in order to avoid interference. The specific content of the OFS Interference Avoidance Information is a detail for the JTC to define. The JEM recommends that:

   - before initiating any transmissions, the air interface standard(s) require portables/mobiles to obtain OFS Interference Avoidance Information.

   - the OFS Interference Avoidance Information is downloaded in some fashion to, or otherwise determined at, the PCS base stations and then subsequently transferred to the portable via PCS set-up/control signaling functions.

   - the air interface standard(s) shall not preclude the base station from obtaining OFS Interference Avoidance Information from portables/mobiles.

     (The intent of this last statement is to allow the bi-directional information flow for those systems that employ this capability.)

- air interface standards include the details of the transmission authorization process (e.g. protocols, channel numbers, etc.).

- the air interface standard(s) should require transmission of information that may be used to facilitate OFS spectrum sharing such as portable/mobile identification, cell/base station identification, system identification, functional capabilities, etc.

4) Some spectrum sharing techniques are essentially independent of the radio access technology, others have intrinsic properties that the technique takes advantage of, while still others are a hybrid of several technologies. In recognition of this fact, and not knowing which technology would used in any air interface standard, the JEM agreed the following statement was important:

   - The access technology, as part of the air interface, is integral to OFS spectrum sharing and should be a consideration.

5) In recognition that some diagnostic PCS to OFS interference determinations may be of value, the JEM recommends that:

   - the air interface standard(s) allow diagnostic system functionality. For example, robust operation should be maintained under temporary conditions of either all base stations or selected groups of base stations simultaneously transmitting.

6) While the main concern with OFS spectrum sharing is to prevent the PCS system from interfering with the OFS, it was felt important to point out that interference from the OFS into PCS is a unique consideration and the JEM recommends that:

   - the air interface standard(s) exhibit robustness in an environment of OFS interference into licensed PCS.

     (The specifics of robust operation and the OFS environment are for the JTC to determine.)

3.2.4.1.3 PCS/PCS Spectrum Sharing Issues and Recommendations

Turning its attention to the impacts and issues relative to spectrum sharing on the air interface between PCS and PCS, the JEM felt that some of the same issues and recommendations apply from the above discussion, specifically:

- the air interface standard(s) should require transmission of information that may be used to facilitate PCS spectrum sharing such as portable/mobile identification, cell/base station identification, system identification, functional capabilities, etc.

- the access technology, as part of the air interface, is integral to PCS spectrum sharing and should be a consideration.

- In recognition that some diagnostic PCS to OFS interference determinations may be of value, the air interface standard(s) shall allow diagnostic system functionality. For example, robust operation should be maintained under temporary conditions of either all base stations or selected groups of base stations simultaneously transmitting.

Some of today's providers in the cellular band wish to provide private services. Recognizing that this may be the case for providers in the 2 GHz band, and knowing that some of the technical issues are related to the air interface standard, the JEM recommends that:

- the air interface standard(s) facilitate private sub-operation (for example, cordless, or wireless PBX) by PCS licensees. While this relates to interference control, it may have broader implications.

In addition, the JEM discussed co-ordination and managing interference (i.e. co-channel and adjacent channel) between operators, which may operate very different systems. This is partly a function of mobiles/portables operation and therefore operators may benefit from new technologies that aid this process. Thus the JEM recommends that:

- the air interface standard(s) allow the transmission of information related to inter-system co-ordination and inter-operability.

The JEM did not have the opportunity to discuss the technical issues of spectrum sharing in the non-licensed band. Therefore, the JEM notes that:

- non-licensed PCS to non-licensed PCS sharing has not been addressed by this JEM. Further work is required by the appropriate organizations.

3.2.5 Reference Information on Technologies and Spectrum Allocation.

Contributions in this JEM presented specific technologies proposed by different companies and some views on the Federal Communications Commission proposed spectrum allocation.

3.3 Related to Objective 3

3.3.1 Introduction

Objective 3: Address the issue of the need and advantages of developing a minimum number of air interface standards, that allow similar applications from a technical and end-user point of view to be served with the same air interface.

Sub-goals of Objective 3 were:

- Identify the advantages and disadvantages of minimizing the number of air interface standards from the point of view of: (1) end users (subscriber -- user of handset), (2) manufacturers, and (3) service providers.

- Determine which of the advantages and disadvantages are affected by the end user's environment (i.e., residential, business, etc.), and how they are affected.

- Develop a weighting of the strength or weakness of each advantage and disadvantage.

- Make recommendations.

In order to meet Objective 3 and its subgoals, the contributions were separated into four categories, which were used to develop four task groups. The task groups were charged with the following items:

Task 1: Advantages of a single Air Interface and advantages of multiple Air Interfaces.

Task 2: Consensus on Air Interface definition and goals.

Task 3: Develop/define an agreeable application environment structure.

Task 4: Comparison and evaluation of common air interfaces for PCS applications.

Contributions were presented in the four task sections. Discussion followed each group of presentations. Two drafting groups were assigned to capture the resulting consensus from each discussion session, and draft the appropriate information and recommendations.

For our analysis, the regulatory environment proposed in the current PCS NPRM (Docket 90-314/92-100) was assumed. A change in the regulatory environment will potentially lead to changes in the air interface solutions.

A weighting of the strength or weakness of each advantage and disadvantage was not performed because it was believed that this is the responsibility of the service providers according to their view of their subscriber requirements and their business strategy. This weighting can not be performed prior to the FCC rulemaking and definition of the potential operators. There were no contributions directly addressing this subject. Instead, the JEM described a recommended method for the comparison of proposed air interfaces in advance of the final FCC rulemaking. This information can later be used to evaluate the proposed air interfaces when the operators and the nature of their system and license are known.

3.3.2 Task 1: Advantages of a Single Air Interface and of Multiple Air Interfaces

This section is the output of Task 1 and is intended to be high-level background information for Task 2.

3.3.2.1 Advantages of a Single Air Interfaces

There are several reasons why a single Air Interface would be most desirable for PCS customers, manufacturers, and network providers. For example, a single Air Interface permits the following:

- facilitates multi-region and nationwide service, e.g., roaming;
- enables interoperability among multiple service providers;
- promotes ubiquity in multiple applications - for example, residence, office and public telepoint;
- creates the ability to place emergency calls from almost any urban, suburban, commercial area;
- minimizes terminal complexity and cost for multiple applications (no multi-Air Interface implementations);
- lowers cost due to high production volume (especially initially), permitting faster PCS launch;
- promotes more competition among manufacturers and providers;
- enables simpler spectrum sharing, due to manageable interference parameters;
- facilitates economical network provisioning, operations, and maintenance;

- improves trunking efficiency in a PCS-PCS shared spectrum environment; and,

- would be more attractive to foreign markets promoting export sales to countries that have no established standard.

3.3.2.2 Advantages of Multiple Air Interface

There are several reasons why multiple Air Interfaces would be most desirable for PCS customers and manufactures. These include:

- the optimization of interfaces to specific applications and environments (e.g., a high bit rate, distributed, wireless LAN versus a medium bit rate, centralized, voice network or a special environment such as the Federal Aviation Administration requirements for passenger communications within an airplane);

- potentially lower cost for simple air interfaces/applications;

- possibly faster time to manufacturing in that narrow standards or proprietary implementations are easier to agree on than broad standards;

- allowance for adoption of other countries' standards that would promote foreign sales;

- possibly more opportunity for product/service differentiation and innovation; and

- a multi-Air Interface terminal accommodates need for multi-application access.

Note: The advantages of a single Air Interfaces and advantages of multiple Air Interfaces listed above are based on Telocator's contributions TR45.JEM/92.11.09.227 (T1P1/92-227) and TR45.JEM/92.11.09.261 (T1P1/92-261).

3.3.3 Task 2: Consensus on Air Interface Definition and Goals

3.3.3.1 Consensus Position

- The industry may have to provide more than one air interface, but only where multiple interfaces are justified or dictated by application needs.

- A flexible air interface is needed; common to voice and low/medium speed data, across multiple applications.

- The industry needs a flexible air interface core with application-driven deltas.

- It is essential to minimize the number of standardized air interfaces spanning licensed and non-licensed spectrum boundaries. At a minimum, it is essential that there is interoperability between the licensed and non-licensed bands for voice and low/medium speed data.

- Standards should be developed to accommodate the end user's perspective.

- The standard(s) should enable a single user terminal to operate across multiple environments for a given set of applications.

- From the user's perspective, the air interfaces shall be transparent, regardless of the final standard.

3.3.3.2 Task 2 Recommendations

In order to accomplish the goals stated in Section 3.3.1, it is recommended that a layered methodology be used to develop the air interface. Such a methodology should separate functions as access-independent and access-dependent. The set of access-independent functions should be maximized to facilitate interoperability across multiple access mechanisms. For example, see Figure 3.3.1[2] below.

[2] This figure is from contribution TR45.JEM/92.11.09.23S (T1P1/92-235).

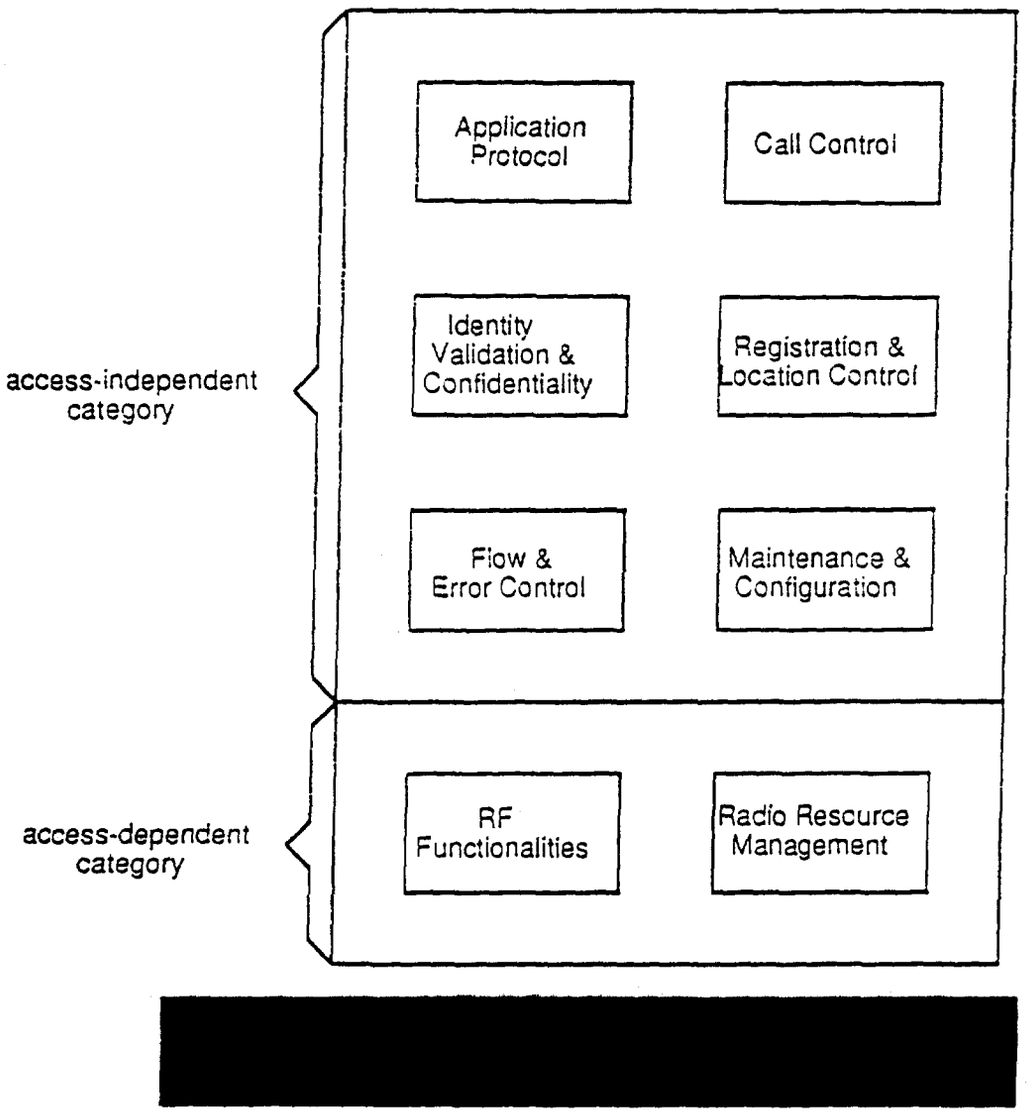

Figure 3.3.1 PCS Air Interface Functional Model

We recommend that the JTC define a flexible air interface and core in accordance with the principles stated above. By way of example of a flexible air interface core, we recommend reviewing the concept discussed in contributions TR45.JEM.92.11.09.241 (T1P1/92-241) and TR45.JEM.92.11.09.242 (T1P1/92-242). These contributions present the concept of a family of air interfaces built on a common core.

The JTC should work with TR45.4 to establish a technical liaison with WINForum to understand the impact of the spectral etiquette being developed by WINForum on radio performance and to coordinate interworking between the etiquette and standards.

3.3.4 Task 3: Develop/Define an Agreeable Application Environment Structure

3.3.4.1 Grouping of Application Environments by Zone.

Note: The following information represents a collection of "Application Environments." An application environment represents the overall situation inside which a particular application will operate. It includes those aspects of the physical environment, regulatory environment, and those aspects of the application that impact the air interface. A "Zone" is a nested group of application environments, which are grouped by high-level characteristics and areas of operation. This example of "Zone" grouping is shown in Figure 3.3.2[3].

[3] The original diagram is in TR45.JEM/92.11.09.232 (T1P1/92-232)